Indirect emissions from rendered animal fats used for biodiesel

Final report Task 4a of ENER/C1/2013-412

- Confidential –

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1 Introduction

This study report is part of the Study on Estimation of indirect land-use change emissions from bioenergy (ENER/C1/2013-412, Task 4a).

1.1 Aim of the case study

The aim of this case study is to estimate to which extent Indirect Land-Use Change (ILUC) would take place following an increased use of animal fats (AF) for biodiesel production. It is based on interviews with relevant stakeholders in the sector (e.g. renderers, biodiesel producers, chemical companies, etc.) and explorative analysis using the evaluation tool developed by IIASA in Task 3. The production of AF does not directly impact land use, as AF are by-products from the meat industry. However, it is possible that an increase in demand for AF, as a result of an incentive towards the use of waste and by-products in EU biofuel policy, could have an impact on the price and availability of AF. Reduced availability and competition with other sectors using AF may lead to substitution effects and ILUC. Where the substitute materials are based on agriculture or forestry, it is possible to estimate an ILUC effect for AF derived biodiesel. Based on the interviews conducted among various experts, this case study assumes that substitution of AF will be mainly by palm oil from South-East Asia.

In addition to LUC emissions, this study also quantifies indirect emissions due to increased use of fossil fuels by renderers in replacement of animal fats, should they become too expensive due to an increased demand from the biodiesel sector.

This report firstly outlines the animal fat market in the EU, based on literature, market data and stakeholder interviews. Subsequently, the evaluation tool (created as part of Task 3 of contract ENER/C1/2013-412) was used to calculate the ILUC impacts and indirect greenhouse gas (GHG) emissions of an increased use of AF for biodiesel production under different scenarios.

1.2 Study scope

This study focuses on rendered animal fats (category 1, 2 and 3) obtained by rendering animal remains after the initial removal of meat, hides and food grade fats are considered. These are fats obtained from internal organs, heads and tissues. Food grade animal fats for human consumption are excluded from the analysis.

Rendered animal fats produced in the EU are divided into 3 categories as defined in the Animal By-Products Regulation 1069/2009.

- **Category 1** (cat 1) material has the highest risk of spreading disease such as BSE and includes the bovine spinal cord, pet animals, zoo and circus animals, wild animals suspected of carrying a disease, and catering waste from international transport. Cat 1 material needs to be disposed of, either by incineration or as a fuel for combustion. If treated correctly, it can be landfilled.
- **Category 2** (cat 2) material is also high risk material including fallen stock, manure and digestive content. Cat 2 is also the default status of any material that does not fall into cat 1 or 3. In addition to the cat 1 fates, cat 2 material may also be used as organic fertiliser and soil improvers and be composted or anaerobically digested.
- **Category 3** (cat 3) material is the lowest risk material. It represents parts of the animals that have been passed as fit for human consumption. However, it is generally not used for human food, either because it is made out of non-edible parts (e.g. hides, hair, feathers, bones) or for commercial reasons. This category of animal fats can also be used for the manufacture of oleochemicals (e.g. soaps, cosmetics, solvents, lubricants), pet food and animal feeds, although there are further restrictions on exactly what can be fed to different types of animals.

Note: Cat 1 and Cat 2 are considered as one group (Cat 1/2) throughout this case study, as their use, market and likely evolution are deemed comparable.

In mixtures of different categories of material, the entire mix is classified according to the lowest category in the mix, since the higher category material would be considered contaminated. For this reason, strict segregation procedures need to be in place for category 2 and 3 material to retain their category status.

For this case study, the animal fats are generally not be broken down into further components (e.g. beef tallow, pork lard, chicken fat), except to illustrate certain economic trends.

2 Animal fats markets in the EU

In an attempt to understand and articulate the animal fats sector in the EU, interviews were conducted among stakeholders from a number of organisations. These include:

- Argent
- Saria
- APAG (European Oleochemicals and Allied Products Group)
- Croda International PLC
- FABRA (Foodchain and biomass renewables association)
- Demeter
- Emery Oleochemicals
- Greenergy
- Neste Oil
- FEFAC (European Feed Manufacturers' Federation)

The following sub-sections are based on these interviews, as well as literature review.

2.1 Availability of animal fats

There is a finite stock of animal fats that can be produced in the EU, which is dependent on the number of animals that are reared, slaughtered and sent to rendering facilities. Figure 1 show data on the volumes of different categories of animal fats produced across the EU. This data is provided by EFPRA, the European Fat Processors and Renderers Association. EFPRA's members represent 93% of the category 1, 69% of the cat 2 and 74% of the cat 3 animal fat produced in the EU and the relative proportions are fairly representative of rendering facilities across the EU.

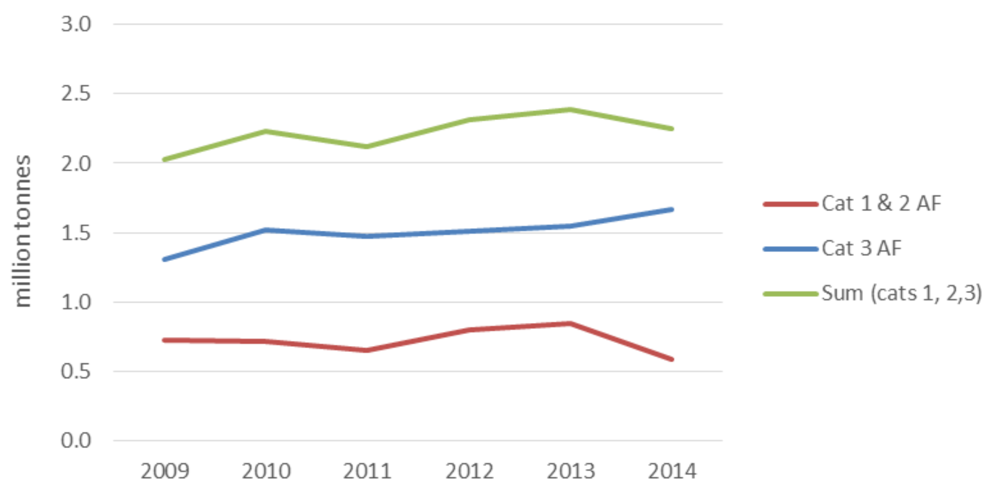

Figure 1: Total production of different categories of animal fats in the EU. Source: EFPRA

As can be seen in Figure 1, the production of animal fat from raw material has been fairly stable over the last 5 years. From year to year there are fluctuations in preferences for different types of animal meats. For example, interviews reveal that the last few years have seen a decline in beef production, a stabilisation of pig meat production and an increase in poultry meat production. Only in recent years has there been a slight increase in the production of cat 3 AFs and a decline in the production of cat 1&2 AFs. This could be explained by an improvement in the segregation processes at the rendering facility to produce more cat 3 material, which receives a higher price. Some of the interviewees suggest that since beef production generates cat 1 material, a decline in beef consumption would lead to a decline in cat 1 production. Another explanation lays with the fact that some MS have lifted restrictions over use of certain AF categories.

Restrictions on cat 1 material are currently being relaxed (Ecofys, 2014), and this trend is expected to continue in the coming years, resulting in a slight increase in cat 3 material and a slight reduction of cat 1 material. However, the exact change in volume is uncertain as it will depend on the extent to which rendering facilities currently producing largely cat 1 material are willing to invest in segregation procedures to produce potentially small additional amounts of cat 3 animal by-products. Increase in cat 3 AF could be significantly offset by incentives over the use of cat 1-2 AF for biodiesel production (e.g. double counting), which might raise the prices of cat 1-2 AF to a point where they would become more profitable than cat 3 AF. This study evaluated to which extent cat 3 AF might be increasingly used to produce biodiesel. This could happen as a result of cat 1-2 AF price increasing above cat 3 AF price or to benefit from double counting via downgrading.

Since countries outside the EU do not have the same categorisation of animal by-products, the possibility to import animal fats, especially from the United States, is currently limited. There are some imports and exports of animal fats from the EU, but the industries that could use cat 1 AFs (i.e. biofuels, rendering, power) appear unlikely to consider AF imports in response to increased competition in the EU, due to the additional costs associated with transporting AFs, compared to substitution by fossil fuels.

2.2 Prices

Typically, cat 3 animal fats (AFs) are more expensive than the other grades of AFs as shown in Figure 2, since they go to the highest value sectors. However, AFs are typically lower in price than vegetable oils such as palm oil. In the model used to estimate ILUC effects of AF (Section 3), average prices for 2014 (Germany) were used for AF 1-2, AF 3 and palm oil (respectively 316.5 EUR/t, 362.4 EUR/t and 399.4 EUR/t). The model would then show the projected prices as a result of a shock in the demand for AF cat 1-2.

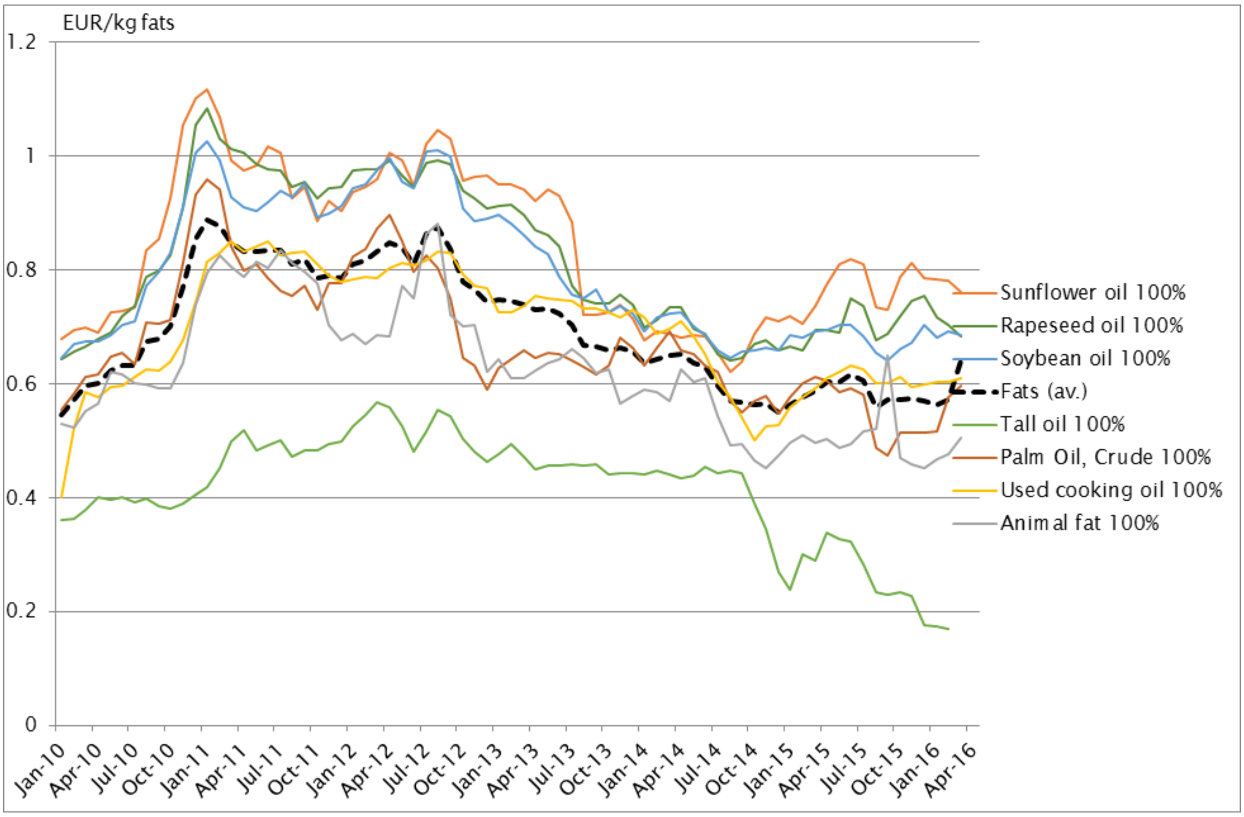

Figure 2: Prices of animal fats relative to palm oil and used cooking oils. Source: F.O. Licht, Oil World (own calculation in task 2 of this project)

A wide variation in the price of animal and vegetable fats can be observed over time. In addition, AFs may not be bought on an open market but instead bought directly from renderers. Other factors that affect the price are the distance which the AFs have to be transported, the time of year, how far in advance you want to secure feedstocks and the exact specification of the AFs. Based on discussions with the rendering industry, there are typically no long-term contracts for animal fats; AFs can typically only be bought up to three months in advance, which is determined by the visibility given by the slaughterhouses that have always worked on these timeframes.

2.3 Uses of animal fats

The key applications for the categories of AFs considered in this case study are:[1]

- As a process fuel in the rendering facility for process heat and power (no data available on this at an EU level)

[1] Source for all values in this section: EFPRA (2015)

- As a feedstock for biodiesel (~400kT cat 1 and 2 AFs and ~300kT cat 3 Afs in 2014)
- As a chemical intermediary for oleochemicals (~580kT in 2014)
- As a precursor for animal feed (farm animal feed used ~600kT AFs and pet food used ~275kT cat 3 AFs and edible AFs in 2014)

AFs are also used in very small quantities in the power generation but this was considered a relatively minor sector compared to others and is therefore not considered further in this case study. Very specific conditions are still required for the disposal of category 1 and category 2 animal fat in power stations, so investment would be required at power stations should they wish to switch to using this feedstock.

The animal feed and oleochemical industries can only use cat 3 AFs, whereas technically, all categories could be used for energy/biofuel production, although some stakeholders report that cat 3 AF are of better quality for biodiesel production. As illustrated in Section 3, this impacts the substitution elasticity for certain sectors, and therefore the ILUC effect of animal fats.

2.3.1 Process fuel and power generation

Depending on the prices of alternatives available, AFs may be burnt at the rendering facility to generate process heat and power or used in local power stations. Typically only cat 1 AFs would be used, as cat 2 and 3 AFs can be sold for a higher price and used in more technical applications. Due to double counting over biodiesel made out of cat 1 and 2 AF, however, the use of AF as process fuel may be increasingly substituted by fossil fuel in the future. In addition, interviews reveal that using AF in rendering plant requires more maintenance (cleaning) work and would make compliance with air pollution restrictions more challenging than when using, for example, animal fat.

Data for the UK shows (Ecofys, 2014) that the volume of animal fat that is combusted as a fuel can vary significantly year on year. In 2013, the proportion of cat 1 AFs used in combustion was 45%, whereas the proportion used in 2014 was 10%. The exact volumes of AFs used depend very much on the price of alternatives that could be used, such as natural gas, coal and heavy fuel oil, and how this compares with the price that the AFs may be sold for. In 2014, with the lower volume of UK cat 1 AF used in combustion, a much higher proportion was used as biodiesel (55% in 2014 compared with 28% in 2013), an extra 6% was exported to the EU and unlike in the previous year, some was used by the EU oleochemical industry.

The rendering industry to some extent already uses AFs as process fuel for heat and power. Depending on whether alternative fuels for the process are cheaper than the price paid for AFs, a rendering facility will potentially sell the AFs and substitute its use in the rendering plant with another fuel, e.g. coal, natural gas or heavy fuel oil. This substitution happens to some extent anyway, depending on the price that might be paid by others (e.g. power stations) for those AFs. However, one can envisage that it would happen to a greater extent if there are more alternative uses for the AFs. What substitute fuel is used may also be specific to the location of the rendering facility; in certain places there may be cheaper or easier access to certain substitute fuels.

Based on the data collected, the scenarios modelled in Section 3, estimates current yearly AF cat 1-2 consumption from the rendering sector at 0.2 Mt. Substitution elasticity towards AF cat 3 or palm oil is considered extremely low due to higher costs. However, potential substitution for fossil fuels is explored in some scenarios, as well as subsequent greenhouse gas emissions due to fossil fuel combustion.

2.3.2 Biofuels

The nature of the demand for AFs for biodiesel has changed somewhat in recent years, as regulations are being introduced which limit the extent to which crop based biofuels can be used as feedstocks. Incentives such as double counting make feedstocks such as used cooking oil more expensive and yet more attractive than palm oil. Further to this, public pressure has forced some companies to change their feedstock sourcing strategy and base it entirely on wastes and residues. For example, Neste Oil intends for all its facilities, including its Singapore plant, to use only wastes and residues as feedstock. This illustrates that there are now other factors at play, other than market price, when it comes to feedstock sourcing for biofuel companies.

Since the end of 2014, there has also been a Russian embargo on the import of animal fats from the EU, which might reduce demand for EU animal fats outside the EU, and therefore price, making these feedstocks even more attractive to biofuel producers through double counting. In addition, some EU Member States, e.g. Finland, cat 3 AFs do count double towards targets. Therefore it is important to consider existing consumers of all three categories of AFs.

In some countries, biodiesel made out of animal fats (AF) count double towards their national renewable energy obligations put on suppliers, if they come from cat 1 or 2 AFs (e.g. UK, NL, FR, DK). In some countries, they count double if they come from any cat of animal fat (e.g. FI, AT). Double counting is a strong incentive to use a particular feedstock. For example, the double counting premium at present in the UK is of the order of €180/t biodiesel, according to an EU biofuel company. Since January 2012, animal fats cat.3 can neither be single nor double-counted towards the biofuel quota in Germany.[2] However, all categories of AFs are being used for biodiesel production, as shown in Figure 3.

[2] German Federal Emissions Act §37b

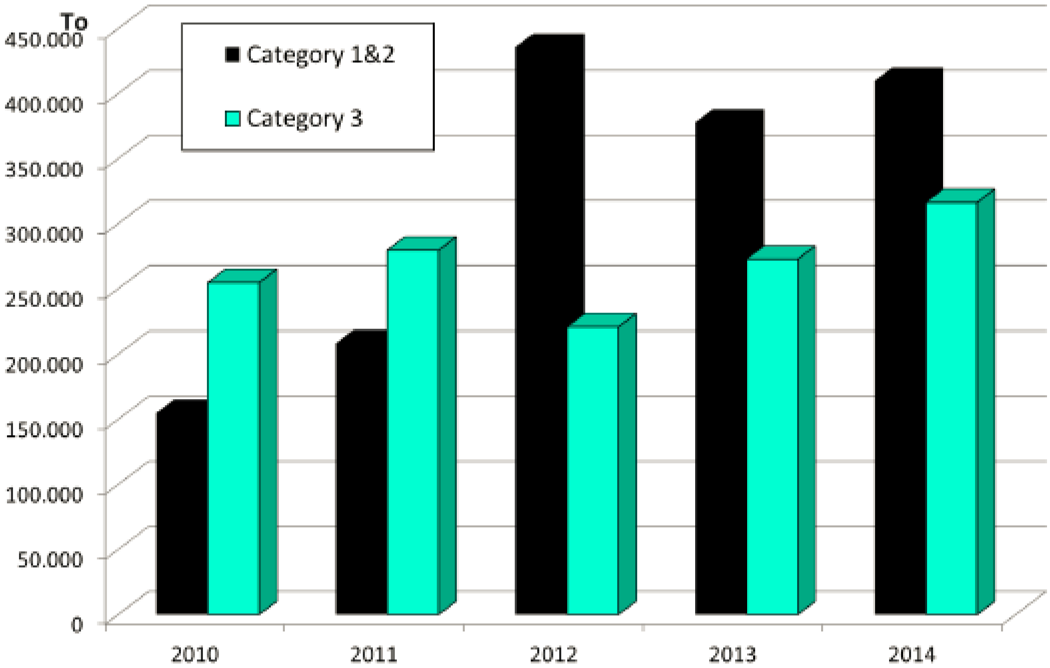

Figure 3: Biodiesel production from different categories of animal fats, across the EU. Source: EFPRA (2015)

Some biofuel producers may only use cat 1 and 2 AFs since they rely on the double counting to make their economics work. However, interviews reveal that some biodiesel producers prefer using cat 3 AFs due to higher quality. In addition, the conversion of facilities to process cat 1&2 AFs[3] requires additional capital expenditures. Given the limited availability of AF cat 1-2 and possible price increases due to enhanced competition, AF cat 3 might become price-competitive with AF cat 1-2, which would drive biodiesel producers to use cat 3, even if it remains single-counted. Concerns exist, however, among some stakeholders that producers or traders may purposefully downgrade cat 3 AFs to cat 1 and 2 AFs to benefit from double counting regimes. However, this practise could be considered questionable by the European Commission, as only categories 1 and 2 can be double counted for reaching the 2020 renewable energy target in transport[4]. In addition, it is argued that it would not make sense for renderers to downgrade cat 3 animal fat because material from which it came from would no longer be considered cat 3, and therefore the proteins made from that material could not be sold as category 3 proteins, which themselves have a high economic value. However,

[3] Some biofuel companies may be limited to only using cat 3 AFs since biodiesel facilities need to be licensed to use cat 1 tallow. This licence demonstrates that the right processes are in place to treat this material for the required time at the required temperature and pressure to neutralise specific contaminants (e.g. BSE prions). In addition, the sulphur content of cat 1 AFs can be quite high and if the biodiesel facility does not have a distillation column, the resulting biodiesel can be off-spec on the sulphur content. If a biodiesel facility has not invested in this kind of equipment, it cannot use cat 1 AFs as a feedstock.

[4] Feedback provided by DG ENER on May 23, 2016 (Brussels)

there may always be a risk of a fraud, by transporting the cat 3 AFs to a cat 1 facility for example. Others have also pointed out that edible fats could also be downgraded and that this may explain the dip in in the production of food grade tallow and lard since 2012 (see Figure 4 – tallow and lard, along with chicken fat, are the main components of animal fats). However, there may also be very legitimate reasons for this dip, such as particular diseases in these years that have resulted in more food grade AFs rendered unfit for human consumption.

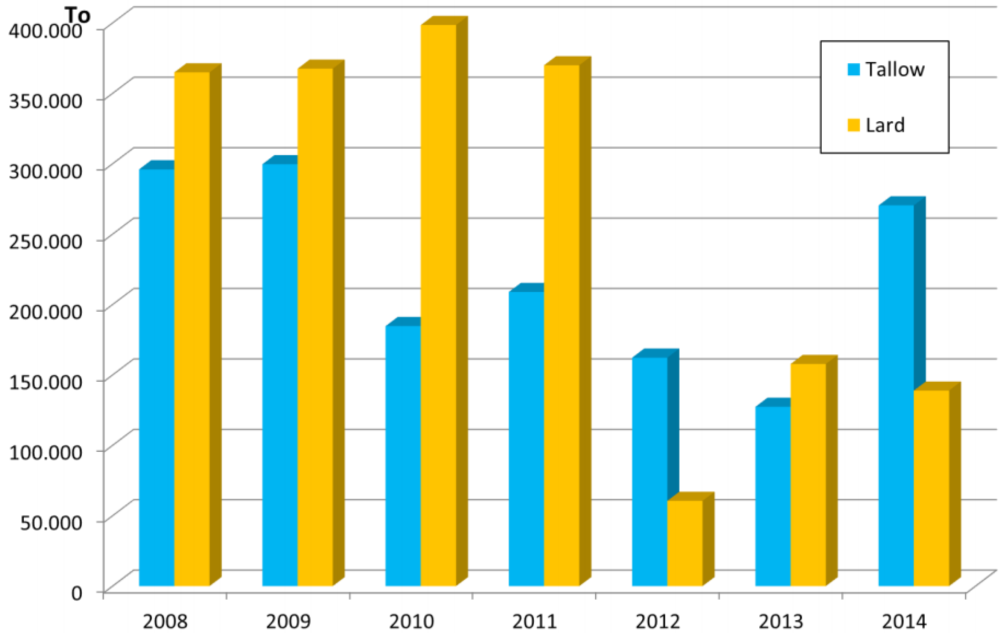

Figure 4: Production of food grade tallow and lard. Source: EFPRA (2015)

In the model used in this study to evaluate ILUC emissions, an increased use of AF cat 3 for biodiesel production was included in certain scenarios. This could either occur as a result of an increase in cat 1-2 price up to a point where it would be more profitable to produce single-counted AF cat 3 biodiesel than double-counted AF cat 1-2 biodiesel, which would be legal. An increased use of cat 3 biodiesel could also be foreseen through the deliberate illegal downgrading of cat 3 AF as cat 1-2 AF to benefit from double counting regime. The model used in this study does not differentiate between these two alternatives, as in both cases, an increased amount of AF cat 3 would be used for biodiesel production, which would create competition with other sectors using AF cat 3, and therefore ILUC.

An increased use of AF cat 3 for biodiesel production is explored in Section 3. Based on the data collection conducted for the purpose of the current study, the consumption of AF cat 1-2 and AF cat 3 by the biodiesel industry is estimated at 0.4 Mt/year and 0.3 Mt/year respectively. While the demand elasticity for the biodiesel industry is considered nil, a high substitution elasticity is assumed in certain scenarios, which correspond to an increased use of cat 3 for biodiesel production (through downgrading of cat 1-2 or not) and substitution of AF cat 3 by palm oil in other sectors.

2.3.3 Oleochemicals

Note: Companies that are not using AFs as feedstock are not included in the "oleochemical industry" throughout the document.

The oleochemical industry produces three commodity chemicals from cat 3 AFs, these are fatty acids, fatty alcohols and glycerine:[5]

- Fatty acids are largely used for making soaps and detergents, other intermediates, plastics, rubber, paper, lubricants, coatings and resins, personal care items, food and candles.
- Fatty alcohols are used for soap and detergents, personal care items, lubricants and amines.
- Glycerine is used for soap, cosmetics and pharmaceuticals, alkyd resins, food, polyurethane, tobacco, explosives

As shown in Figure 5, the oleochemical and animal feed market are the biggest markets for cat 3 AFs (and edible AFs).

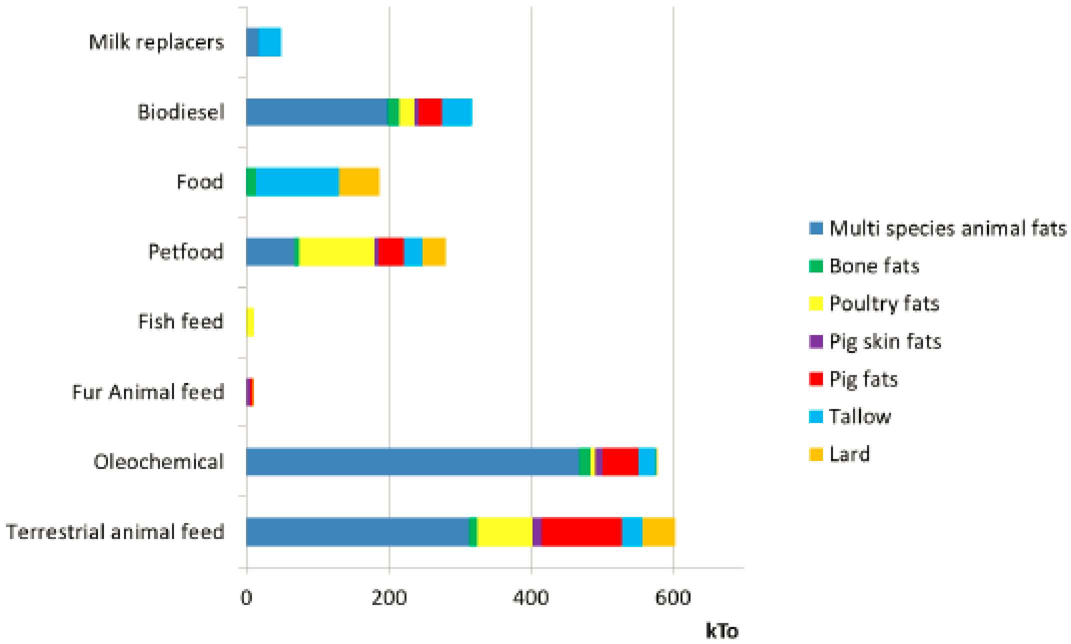

Figure 5: Destination of edible and category 3 fat in 2014. Source: EFPRA

[5] AEA, E4tech, Metroeconomica, Miller-Klein (2008) Advice on the Economic and Environmental Impacts of Government Support from Biodiesel Production from Tallow

The type of AF used by the oleochemical industry in Europe is mainly cat 3 AFs; only 2% of oleochemicals in Europe were sourced from cat 1 and 2 AFs in 2014 (EFPRA, 2015).

However, the oleochemical industry in Europe is not homogeneous. There are companies which still use traditional feedstocks such as AFs produced in the EU, and there are other companies that have merged with Indonesian and Malaysian companies and no longer use these traditional feedstocks but instead use palm oil (fruit and/or kernel), not bought on the market but sourced through their vertically integrated companies.

According to the representatives of the EU oleochemical industry interviewed for this project, the additional support given to biofuel producers in the form of double counting increases the price of all categories of feedstock, including category 3 feedstock that they wish to use for oleochemicals. As noted earlier, since AFs do not get sorted into the same categorisation outside the EU, it is not possible to import cat 3 AFs into the EU and thereby expand the pool of feedstocks available to the EU oleochemicals industry (and biodiesel industry).

As the price of AFs increase and competition for AF will likely become more intense, it becomes pertinent to understand what options are open to the oleochemical industry to substitute for the AFs. According to the industry, palm oil is the best substitute for AFs, since it is the closest chemically to AFs; i.e. it has suitable proportions of oleic and stearic acids which are required for the products they make from the fats.

However, substituting animal fats with palm oil can be economically damaging for companies without vertical integration of palm production (see above), due to higher trading prices Since 2011, Indonesia has discouraged crude palm oil exports, in order to encourage value added industries to develop there, by having a lower export tax on refined palm oil products, than on crude palm oil. This resulted in a wave of capacity building to make refined palm oil, as crude palm oil products are barely profitable. Companies are now focusing on oleochemicals made from refined palm products to increase their margins.

Without access to low cost AF feedstocks, some players fear that the EU oleochemical industry will fold and EU oleochemical demand will be displaced onto palm oil production in SE Asia. in addition to the economic risks for oleochemical companies, palm oil production is currently marked with a high greenhouse gas intensity from land-use change (8.2 t CO_2 eq/t of PO) due to the assumption that new palm plantation will be planted on drained peat swamps or deforested areas. A global application in certification of palm oil imports to a credible sustainability standard (e.g. RSPO, Rainforest Alliance) would significantly reduce environmental and socio-economic risks in palm production areas, and therefore decrease the GHG intensity from land-use change.

In Section 3, the current annual consumption of AF cat 3 and palm oil by the oleochemical industry is estimated at 0.6Mt and 0.7Mt respectively. A very low demand elasticity is attributed to this sector and a limited substitution elasticity is tested in certain scenarios.

2.3.4 Animal feed

FEFAC, the European Feed Manufacturers' federation does not collect industry wide data on the proportion of the fat in its feed that comes from animal fats and the proportion that comes from vegetable oils. This can be explained by the fact that only 2% of industrial compound feed is made up of fats and oils (personal communication, FEFAC). The main types of vegetable oils that are used in feed are palm oil and rapeseed oil. Other oils e.g. soybean oil or sunflower oil are used at lower levels. The fatty acid composition of the fats or oils used is important not just for the nutrition of the animal but it also has implications on the quality of the final meat – e.g. saturated fatty acids are preferred for chicken feed as it increases the chicken meat's firmness.

In the UK, the animal feed industry for consumable products does not use AFs from land based animals. However, in mainland Europe, the restrictions on using AFs in animal feed are different; in general animal fats can be used in animal feed. However, there is still some market resistance to using animal fats in feed, even though it has been deemed safe in the legislation. Furthermore, in Germany, there are additional national regulations which mean that no animal fats are used in feed there. Thus there are still some market and legal barriers which limit the extent to which it is used in this sector.

The animal feed industry also uses cat 3 AFs. As for the oleochemical industry, it is not possible to import cat 3 AFs from outside the EU, so the pool of available feedstock is limited to what is available in the EU. However, the animal feed industry only sees the fat portion of the animal feed as a minor component and so the importance of the availability of animal fats is not seen as so critical to this sector.

The animal feed sector appears to be able to substitute its animal fat use fairly easily with vegetable oils such as crude palm oil and palm fatty acids and rapeseed oil. Other oils that may be used include soybean and sunflower oil. But these oils are not considered to have as desirable properties as palm and rapeseed.

2.4 Potential substitution effects taking place

Task 4a aims to estimate the effect of an increased consumption of animal fats cat 1-2 by the biodiesel industry. By decreasing the available supply of AF cat 1-2, biodiesel would drive prices up, thus possibly leading to substitution in other sectors, which would use alternative products in replacement, including the biodiesel industry itself turning to AF cat 3. This section describes to which extent the different sectors covered in Task 4a could replace AF cat 1-2, based on the interviews conducted.

- **Rendering industry:** Natural gas, coal or HFO would likely replace AF (with varying increases in emissions compared with AF). Technically this AF could be imported from outside the EU but this is unlikely to make economic sense for process fuel.

- **Animal feed:** The animal fat would be replaced by crude palm oil and rapeseed oil. More AF could not be imported from outside EU because outside the EU there is not the same categorisation of animal fats.
- **Oleochemicals:** This could potentially be replaced by palm oil as a feedstock due to similar chemical properties, or potentially more likely, by palm based products produced in SE Asia. Used cooking oil seems an unlikely substitute due to the double counting regime for biofuels and difference in chemical composition (Volatile quality - as UCO can consist of different vegetable oil the length of the carbon chain cannot always be guaranteed, this however is an essential criteria for the processing into oleochemical products.[6]) More cat 3 would not be imported from outside EU because outside the EU there is not the same categorisation of AFs, so all imported AF is considered to be cat 1.
- **Biofuels:** As imports of AF are highly unlikely, biodiesel producers may consider using AF cat 3 for single counted biodiesel, either for quality reasons (See Section 2.3.2) or because of an increase in AF cat 1-2 prices. There is also a possibility for a deliberate labelling of AF cat 3 as cat 1-2 (downgrading) to benefit from double counting regimes, although this would not modify the modelling results. Biodiesel producers may also consider an increased use of palm oil should AF prices become too high.

[6] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels

3 Modelling of ILUC impacts

Potential ILUC impacts of an increase in AF consumption in the EU were explored using an ILUC evaluation tool specifically developed in this project. This tool, based on a partial equilibrium framework, represents in a stylised form the different markets displacements associated to a change in AFs use as biofuel (also called "shock"). The full description of the evaluation tool is available in the 'Evaluation Tool user guide' (IIASA 2016)

3.1 Current demand, supply and prices

The data collected through literature review and interviews were used to evaluate current AF and palm oil demand levels by the different sectors considered in this project, as summarised in Table 1.

Demand (Mt)	Biodiesel[7]	Oleochemical	Rendering	Feed	Food	Total
Cat 1&2 AF	0.4	0	0.2	0	0	0.6
Cat 3 Afs	0.3	0.6	0	0.7	0	1.6
Veg oil	2	0.7	0	1.4	3	7.1

Table 1: Current demand levels for animal fats and palm oil in the different sectors considered

Similarly, Table 2 describes the estimated current supply levels used in the evaluation tool as reference.

	Supply (Mt)
Cat 1&2 AF	0.6
Cat 3 AF	1.6
Palm oil	7.1

Table 2: Current supply levels for the different feedstocks considered

[7] In the evaluation tool, two entries were used for biodiesel, one of which was used to simulate two types of substitution, one by vegetal oil, one through downgrading. For the purpose of the report, biodiesel values are consolidated into one entry.

The prices used in the evaluation tool were the average 2014 AF prices in Germany (316.5 EUR/t and 362.4 EUR/t for AF cat 1-2 and cat 3 respectively) and the average 2014 palm oil price from ARA (and 399.4 EUR/t).

3.1.1 Parameters

The evaluation tool is used to estimate the effect of a "shock" in the demand for animal fats cat 1-2, i.e. an increase in the demand by the biodiesel sector, which could be induced, among other things, by policy incentives such as double counting. Three sizes of shock were tested in this evaluation:

1) High shock: increase of demand in AF cat 1-2 by 0.5 Mt (corresponding to almost the entire current production – see Table 2);
2) Medium shock: increase of demand in AF cat 1-2 by 0.3 Mt;
3) Small shock: increase of demand in AF cat 1-2 by 0.2 Mt.

Response to the shock for different scenarios is evaluated by adjusting different parameters, including:

- Changes in the supply of AF and PO (supply elasticity);
- Changes in the demand for AF and PO from the different sectors (demand elasticity);
- Feedstock substitution (substitution elasticity).

The evaluation tool provides an estimate of the effect of the shock on the above parameters, as well as the impact on the prices of AF cat 1-2, cat 3 and palm oil, as well as the ILUC-induced CO_2 emissions generated by each additional ton of AF cat 1-2 required by the biodiesel industry.

In the specific scenarios where renderers would substitute animal fats with fossil fuels, indirect GHG emissions from the combustion of fossil fuel are estimated in addition to ILUC emissions.

3.2 Scenarios

Scenarios were built around different assumptions regarding the elasticities of supply, demand and substitution of the different sectors which currently consume AF cat 1-2.

The **supply elasticity** was deemed nil for AF cat 1-2 and cat 3, given that they represent a by-product from the meat industry and their production within the EU cannot be increased by the sole demand from the biodiesel industry. Imports from US are currently limited and were not modelled. Palm oil is therefore considered the only feedstock with supply elasticity; following recommendations from Hertel (2007), the supply elasticity for palm oil was estimated at 3.3.

The **demand elasticity** was deemed nil or very low for all sectors considered in the study, with the exception of the rendering sector: in scenarios where the possibility for renderers to substitute AF for fossil fuel, a high demand elasticity (5) was used.

The **substitution elasticity** was deemed very low (0.2) in the rendering and food industry, given that only one feedstock is currently used. The substitution elasticity for oleochemical industry was 0 in scenarios where the shock was deemed to not affect AF cat 3 prices and 1 where AF cat 3 prices were impacted. In order to integrate the possibility of an increased use of AF cat 3 instead of cat 1-2 (which includes single-counted cat 3 biodiesel and the deliberate downgrading of cat 3 into cat 1-2 to benefit from double-counting regime) by the biodiesel industry, moderate (5) and high (10) substitution elasticities were tested for biodiesel.

16 scenarios were tested through the evaluation tool (full description of scenarios is available in Appendix I), the objective being to test variations in the elasticities and shock sizes. The possibility for renderers to replace AF by fossil fuels in their processing was also explored, as it could yield to indirect GHG emissions.

Several scenarios were deemed unrealistic, based on the resulting forecasts in terms of AF and palm oil prices. "Realistic" scenarios are those for which AF cat 1-2 prices are either inferior, equal or reasonably superior to AF cat 3 prices (Table 3), with the exception of scenario 1a, which was retained to illustrate the possible effect of a high shock combined with a restriction on the use of AF cat 3 for biodiesel (in such case, the model results in AF cat 1-2 skyrocketing above 18'000USD/t!). The "blue" scenarios assume a high shock; "yellow" scenarios all assume a medium shock; finally, the "green" scenarios assume a low shock. Variations among scenarios regard the difference in substitution from the oleochemical industry as a result from the shock, whether renderers might substitute animal fats for fossil fuels and whether AF cat 3 would be used for biodiesel ("downgrading").

Scenario #	Description	Shock size Mt	Demand elas	Substitution elasticities		
			rendering	BD1	BD2	oleochem
1a	High shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.5	0.2	1	10	0
1c	High shock. Increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.5	5	1	10	0
2b	Medium shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.3	0.2	1	10	0
2c	Medium shock. Increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.3	5	1	10	0
2f	Medium shock. Increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	0.3	5	1	10	1
3b	Low shock. No ncreased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.2	5	1	1	0
3d	Low shock. Moderate increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	0.2	5	1	5	1
3e	Low shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.2	0.2	1	10	0

Table 3: Scenarios used in the evaluation tool[8]

3.3 Results

Table 4 describes the indirect greenhouse gas emissions from an increase in AF consumption by the biodiesel sector in EU, based on the results obtained via the evaluation tool (expressed in tCO_2eq/t of AF cat 1-2). Indirect emissions include both ILUC emissions and emissions from substitution by renderers towards fossil fuels (three variations are tested here: coal, oil and natural gas). The total adds up ILUC and fossil fuel emissions.

The main result is that there would indeed be a significant indirect impact of an increased use of animal fats for biodiesel production. Considering ILUC emissions only, results show significant

[8] All other elasticities remain constant

variations (from 1.5 to 4.9). As mentioned in the previous section, scenario 1a yields unrealistic results in terms of price changes and is therefore not considered in the analysis of ILUC emissions.

When considering additional emissions from fossil fuel in scenarios where renderers substitute AF with fossil fuels, variations between the scenarios tend to decrease (2.1 to 4.8), the demand elasticity from the rendering industry being a key driver(e.g. comparing scenarios 2b and 2c).

Scenario #	Description	Indirect GHG emissions (tCO2eq/t cat 1&2 af)				
		ILUC	coal	oil	nat gas	**Total**
1a	High shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	**11.5**	1.0	0.8	0.5	**12.1 to 12.5**
1c	High shock. Increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	**3**	1.8	1.4	1.0	**4 to 4.8**
2b	Medium shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	**4.9**	0.0	0.0	0.0	**4.9**
2c	Medium shock. Increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	**1.9**	2.3	1.7	1.3	**2.1 to 3.2**
2f	Medium shock. Increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	**2.8**	2.1	1.6	1.2	**4 to 5**
3b	Low shock. No ncreased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	**1.5**	3.2	2.4	1.8	**3.2 to 4.7**
3d	Low shock. Moderate increased use of AF3 for Biodiesel. Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	**1.9**	2.5	1.9	1.4	**3.3 to 4.5**
3e	Low shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	**3.7**	0.0	0.0	0.0	**3.7**

Table 4: Indirect CO2 emissions from animal fat biodiesel (Note: indirect emissions are expressed in tCO_2eq/t cat 1&2 animal facts consumed)

3.3.1 Interpretation

Because the evaluation tool only looked at a limited scope of products and variables and assumptions were not supported by sound econometric research, results shall not be considered as accurate projections. However, they provide meaningful trends, with regards to the most impactful factors in terms of indirect GHG emissions from an increased used of animal fats by the biodiesel industry.

An increased use of AF cat 3 instead of cat 1-2 reduces ILUC emissions. Additional scenarios (1a-bis and 2a-bis) are included in Table 5**Error! Reference source not found.** to illustrate the effects of a restriction on downgrading, which is modelled by reducing substitution elasticity in the biodiesel sector to the minimum. When comparing scenarios 1a-bis and 2a-bis to scenarios 1a and 2a respectively, two observations can be made:

- ILUC emissions are significantly higher due to the massive shift from biodiesel producers towards palm oil;
- Prices for both AF cat 1-2 and cat 3 tend to skyrocket above realistic thresholds (up to 24'000 USD/t)

This means that an increased use of AF cat 3 for biodiesel instead of cat 1-2 (either as single-counted biodiesel or as double-counted biodiesel, which would involve a deliberate downgrading of AF cat 3 as cat 1-2) would be very likely if a shock of high or medium size was to occur.

Scenario #	Description	Shock size Mt	Substitution elasticities BD1	BD2	oleochem	rendering	feed	food	Result tCO2e/t cat 1&2 af
1a	High shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.5	1	10	0	0.2	0.8	0.2	9.83
1a-bis	High shock. No increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.5	1	1	0	0.2	0.8	0.2	24.08
2a	Medium shock. Increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.3	1	10	0	0.2	0.8	0.2	4.18
2a-bis	Medium shock. No increased use of AF3 for Biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	0.3	1	1	0	0.2	0.8	0.2	7.78

Table 5: Additional scenarios without an increased use of AF cat 3(1a-bis and 2a-bis) (Note: indirect emissions are expressed in tCO_2eq/t cat 1&2 animal facts consumed)

A restriction on the use of AF cat 3 for biodiesel production would yield slightly more moderate effects in a low shock scenario, although price increase for cat 1-2 would be significant (up to 938 USD/t vs 572 USD/t for AF cat 3), as shown in Appendix I (scenarios 3a and 3e). However, here again, where downgrading is not allowed, the biodiesel industry would be expected to use more palm oil, thus resulting in higher ILUC emissions.

Substitution of animal fats by fossil fuels in the rendering industry offsets ILUC benefits. As shown in Table 3, Table 4 and in Appendix I, scenarios which assume that renderers could substitute AF cat 1-2 for fossil fuels generally show lower ILUC emissions (<2), as this substitution would relax AF cat 1-2 for other sectors to use. However, the combustion of fossil fuels in the rendering process tends to offset this benefit by adding 0.5 to 3.2t CO_2 eq for each ton of additional AF cat 1-2 claimed by the biodiesel industry. It should be noted that the use of coal in replacement of AF cat 1-2 leads to the highest emissions, followed by heating oil and natural gas.

An increase in substitution elasticity for the oleochemical sector, even limited (elasticity = 1), increases ILUC emissions, as shown in scenarios 1e and 1f, with respectively 3.04 tCO_2eq/t of AF cat 1-2 and 3.42 tCO_2eq/t of AF cat 1-2 respectively). As this two scenarios include downgrading of AF cat 3 to cat 1-2, this could be explained by the fact that a decrease in the availability of AF cat 3 and subsequent price increase would push the oleochemical sector could substitute AF cat 3 for palm oil, which is not permitted in scenario 1f (substitution elasticity = 0).

The possibility to use AF cat 3 for biodiesel and/or the relaxing of animals by renderers attenuates the impact of the shock size. In scenarios without an increased use of AF cat 3 or substitution with fossil fuels by renderers, the size of the shock amplifies ILUC emission. For instance, in scenarios 1a-bis, 2a-bis (Table 5) and 3a (Appendix), ILUC emissions are respectively 24.1, 7.8 and 5.2 tCO_2eq/t of AF cat 1-2. When comparing scenarios 1c (High shock), 2c (Medium shock) and 3d (Low shock), which allow for some cat 3 into biodiesel production and substitution by renderers, the iLUC emissions are respectively 2.98, 1.87 and 1.95 tCO_2eq/t of AF cat 1-2. Note that the reason for the slightly lower emissions in scenario 2c, compared to 3d is that the only a moderate increase in use of cat 3 AF is modelled in 3d.

4 Conclusions and recommendations

This study quantifies indirect emissions from both indirect land use change and fossil fuel displacement from the use of rendered animal fats for biodiesel in the EU. For the modelling, an ILUC evaluation tool is used that has been developed by IIASA for the European Commission. Results from the evaluation tool need to be considered carefully in light of the simplified approach used and estimates based on data collection. Consequently, this study should not be used to extract single-point data, but to understand how the different economic parameters considered may influence indirect GHG emissions of an increased use of animal fats by the biodiesel industry, all other things equal. Importantly, this study illustrates that an increased use of animal fats by the biodiesel industry would lead to indirect effects through ILUC and fossil fuel combustion.

The lowest value obtained in Table 4 (2.1 tCO_2eq/t of AF cat 1-2 corresponds to 53.3gCO_2eq/MJ of AF cat 1-2, which is comparable to the mean ILUC Factor used for oil crops in the recent ILUC directive[9]. Interestingly, an increased used of AF cat 3 instead of cat 1-2, either as single-counted biodiesel or through a deliberate downgrading of cat 1-2 as cat 3 to benefit from double counting, would reduce ILUC emissions and price effects, all other things equal. An increased use of AF cat 3 and/or the substitution of animal fats by fossil fuels in rendering facilities also results in attenuating the size of the shock.

The simplification of assumptions in this study might constitute sources of uncertainty however. Future studies could therefore focus on improving certain elements, such as:

- The different elasticities explored in the evaluation tool should be further refined and cross-checked with econometric data;
- The likelihood of renderers to use fossil fuels in replacement of animal fats should be further investigated;
- Different assumptions regarding substitution by vegetal oil should be explored, as Task 4a built upon the general assumption that an increased demand for vegetal oil would systematically be fulfilled by palm oil;
- Possible distinction between different palm oil grade (crude palm oil vs refined and bleached oil; fruit oil vs kernel oil; palm oil vs palm fatty acid distillates), which could impact price, supply and demand projections;
- Expand geographic scope beyond EU and explore the possibility of animal fat imports, which could change in the future, thus adding to the existing supply and reducing ILUC effects;

[9] Annex V http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L1513&from=EN

- Evaluate potential improvements in the recovery of waste in the meat industry, which might as well increase the supply of AF and reduce ILUC effects through an increased production of palm;
- Understand to which extend double-counting might incentivise deliberate downgrading of AF cat 3 into cat 1-2.

5 References

Ecofys (2014) *Status of the tallow (animal fat) market – 2013 Update.* Sacha Alberici, Gemma Toop, Ulf Weddige. By order of UK Department of Transport (DfT).

EFPRA (2015) *Statistical overview of the animal by-products industry in the EU in 2014.* Presentation by Dirk Dobbelaere at the EFPRA Congress in Cracow on 5/06/2015. Available at: http://efpracracow2015.com/upload/conf/DD%20cracow%202015.pdf

IIASA (2016) Evaluation Tool user guide. Prepared for the European Commission as part of Task 3 of contract ENER/C1/2013-412

Appendix I – Scenarios used in the evaluation tool

Scenario #	Short Name	Description	Shock	Shock size Mt	Supply elasticities Cat 1&2 AF	Cat 3 AF	Palm oil	Demand elasticities biodiesel 1	biodiesel 2	oleochem.	rendering	feed	food	Substitution elasticities BD1	BD2	oleochem	rendering	feed	food	Result tCO2e/t cat 1&2 af
1a	HS-D	High shock. Increased use of AF cat 3 for biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	10	0	0.2	0.8	0.2	11.51
1a-bis	HS	High shock. No Increased use of AF cat 3 for biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	1	0	0.2	0.8	0.2	24.08
1b	HS-D+	High shock. Increased use of AF cat 3 for biodiesel. + elast. subs in BD1. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	0.2	0.2	0.2	5	10	0	0.2	0.8	0.2	4.01
1c	HS-D-Rd	High shock. Increased use of AF cat 3 for biodiesel.Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	5	0.2	0.2	1	10	0	0.2	0.8	0.2	2.98
1d	HS-D-OL	High shock.Increased use of AF cat 3 for biodiesel.Shock does affect Cat 3 prices so response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	10	1	0.2	0.8	0.2	10.34
1e	HS-D+-Rd	High shock. Increased use of AF cat 3 for biodiesel. + elast. subs in BD1. . Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	5	0.2	0.2	5	10	0	0.2	0.8	0.2	3.04
1f	HS-D+-Rd-OL	High shock. Increased use of AF cat 3 for biodiesel.+ elast. subs in BD1. . Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	cat 1&2 AF	0.5	0	0	3.3	0	0	0.2	5	0.2	0.2	5	10	1	0.2	0.8	0.2	3.42
2a	MS-D	Medium shock. Increased use of AF cat 3 for biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.3	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	10	0	0.2	0.8	0.2	4.18
2a-bis	MS	Medium shock. No increased use of AF cat 3 for biodiesel.Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.3	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	1	0	0.2	0.8	0.2	7.78
2b	MS-D	Medium shock. Increased use of AF cat 3 for biodiesel. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.3	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	10	0	0.2	0.8	0.2	4.9
2c	MS-D-Rd	Medium shock. Increased use of AF cat 3 for biodiesel.Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.3	0	0	3.3	0	0	0.2	5	0.2	0.2	1	10	0	0.2	0.8	0.2	1.87
2d	MS-D-OL	Medium shock. Increased use of AF cat 3 for biodiesel.Shock does affect Cat 3 prices so response from oleochemicals.	cat 1&2 AF	0.3	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	10	1	0.2	0.8	0.2	4.92
2f	MS-D-Rd-OL	Medium shock. Increased use of AF cat 3 for biodiesel. Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	cat 1&2 AF	0.3	0	0	3.3	0	0	0.2	5	0.2	0.2	1	10	1	0.2	0.8	0.2	2.78
3a	LS	Low shock. Increased use of AF cat 3 for biodiesel.Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.2	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	1	0	0.2	0.8	0.2	5.2
3b	LS-Rd	Low shock. No increased use of AF cat 3 for biodiesel.Renderers substitute AF w FF. Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.2	0	0	3.3	0	0	0.2	5	0.2	0.2	1	1	0	0.2	0.8	0.2	1.46
3c	LS-D(-)-OL	Low shock. Moderate increased use of AF cat 3 for biodiesel.Shock does affect Cat 3 prices so response from oleochemicals.	cat 1&2 AF	0.2	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	5	1	0.2	0.8	0.2	4.66
3d	LS-D(-)-Rd	Low shock. Moderate increased use of AF cat 3 for biodiesel. Renderers substitute AF w FF. Shock does affect Cat 3 prices so response from oleochemicals.	cat 1&2 AF	0.2	0	0	3.3	0	0	0.2	5	0.2	0.2	1	5	1	0.2	0.8	0.2	1.95
3e	LS-D	Low shock. Increased use of AF cat 3 for biodiesel.Shock does not affect Cat 3 prices so no response from oleochemicals.	cat 1&2 AF	0.2	0	0	3.3	0	0	0.2	0.2	0.2	0.2	1	10	0	0.2	0.8	0.2	3.7

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